A TRAINING PROGRAM FOR HIGHWAY ENGINEERS

ARIZONA HIGHWAY DEPARTMENT PHOENIX, ARIZONA

Honorable Jack Williams
Governor of Arizona

Justin Herman
Director

Wm. N. Price
State Highway Engineer

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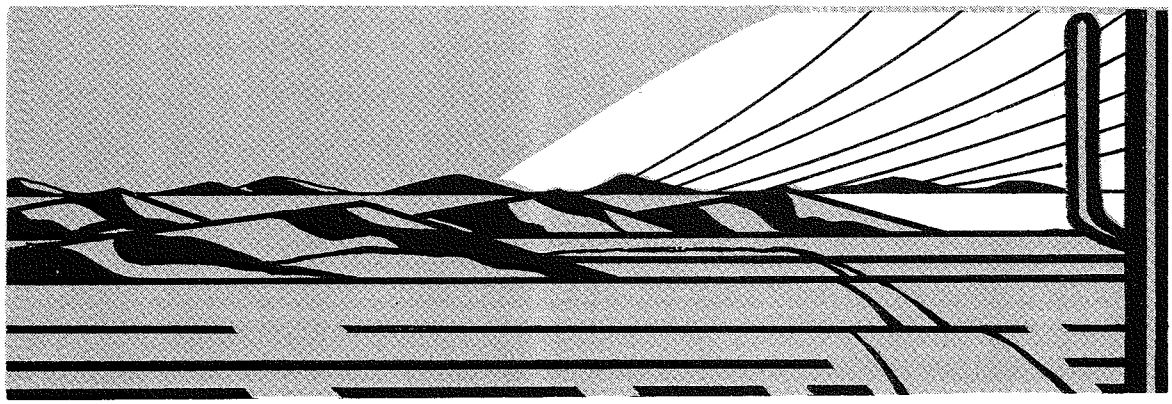
1970



HISTORY OF THE ARIZONA HIGHWAY DEPARTMENT

From territorial days, when roads consisted largely of trails, until the present time, transportation problems have expanded as has population. The First Territorial Assembly authorized toll road companies in an endeavor to provide resources for road construction. In addition to the construction of roads, wells were dug and maintained at necessary points across the desert.

In 1871, toll road owners were permitted to incorporate under county authority, and the counties were permitted to buy these privately constructed roads if they so desired.

The First Territorial Assembly declared certain roads then existing "free roads" because of common usage. Succeeding assemblies incorporated other toll roads.

The Assembly of 1866 authorized county officials to divide the counties into road districts and to appoint overseers to supervise the roads in each district. At this time, a road tax not to exceed five cents on each $100.00 assessed valuation was levied.

Succeeding legislatures authorized counties to issue bonds for road construction, varied the rate of taxation, and added legislation essential to conduct road activities within the counties.

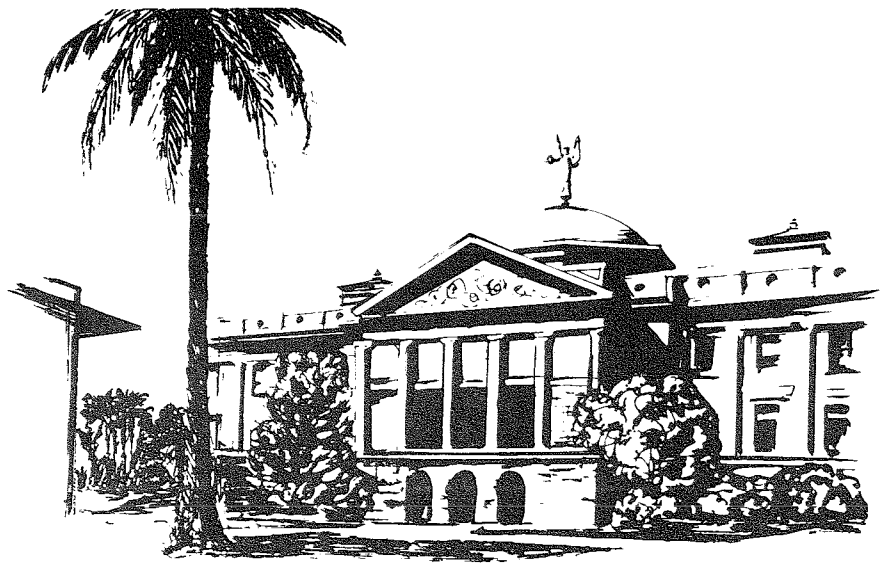
The office of Territorial Engineer was created in 1909 under the supervision of the Board of Control. Upon the admission of Arizona to statehood in 1912, this office became that of State Engineer. In 1917, the office of the State Engineer came under the control of the newly created Commission of State Institutions and so continued until 1919 when the Commission was changed to the Board of Directors of State Institutions.

In August, 1927, the Legislature established the Arizona State Highway Commission and the State Highway Department. This legislative act directly established the first systematic code for the administration of all matters directly affecting the highways throughout the state.

A system of proposed state highways was established. This system was to be improved and maintained and consisted of such parts of the State routes as were accepted and approved by the Highway Commission. In February, 1939, the Legislature amended the existing code and divided the State into five highway districts, with one commissioner appointed from each district. These appointments are so made that only one vacancy shall occur annually.

The five cents per $100.00 property tax for roads which produced approximately one-half million dollars annually, remained in effect until June, 1912. After this date various tax rates followed and general fund appropriations for road purposes were made up until 1933.

Since 1933 all State Highway revenue has come from motor user taxes or federal-aid. From a one cent per gallon tax levied in 1921, the state motor fuel tax has grown to seven cents per gallon. This rate has been in effect since July 1965. The State Highway Fund share was over $32,500,000 from motor fuel tax in 1968 and an additional $20 million was netted from other motor vehicle fees. These amounts are supplemented by federal-aid participation which varies from $60 million to $70 million annually. After expenditures for Maintenance, Administration, and Highway Patrol of approximately $30,000,000, a construction program approximating $90,000,000 was possible in the 1968 fiscal year.



ENGINEER-IN-TRAINING PROGRAM

The purpose of the Engineer-in-Training Program of the Arizona Highway Department is to provide an organized program of training to give each new Trainee a broad experience in the various engineering divisions of the Highway Department during the initial stages of his employment. The training program has been arranged to cover an 18 month period and will develop in the young Engineers who join the Department an adequate understanding of the organization and its various functions as rapidly as possible.

The Trainees will thus gain experience and develop their abilities more rapidly than would be possible otherwise. They will meet the staff of the Department and become familiar with the functions and operations of the several Engineering Divisions. During this period their performance will be noted and evaluated and the Trainee will be able to determine what phase of highway engineering is most interesting and suitable to him.

The Highway Department will benefit in the future by having an engineering organization composed of well-trained men who have a broad understanding of the field of highway engineering and who are familiar with the organization.

ADMISSION TO THE TRAINING PROGRAM

Application blanks and information about the Engineer-in-Training Program may be obtained from the Engineer-in-Training Officer, Arizona Highway Department, 206 South 17th Avenue, Phoenix, Arizona.

ELIGIBILITY:

Any graduate from an accredited college or university, who has completed the regular four year course in Civil Engineering and has received the Bachelor of Science degree, or an equivalent degree, will be eligible to apply for admission to this Program. Trainees must be citizens of the United States.

ADMISSION:

Engineering graduates within approximately one year of graduation will be considered for the program on the basis of education, industry, adaptability, personality, and physical fitness. Personal interviews are desirable but application may be made by letter, accompanied by a transcript of college records, recent photograph, and letters of recommendation. It is anticipated that no selection will be made without a personal interview.

DEPARTMENT EMPLOYEES:

Engineers already in the employ of the Highway Department, meeting the eligibility requirements, may make application for transfer to the Training Program. Such application must have the approval of the immediate supervisor and the Engineer-in-Training Officer.

PERSONNEL POLICIES FOR TRAINEES

WORK SCHEDULE:

Trainees will be expected to work an eight hour day for a five-day week, a total of 40 hours. Overtime may be required during any emergency situation without overtime pay.

LEGAL HOLIDAYS WITH PAY:

The following holidays are observed by the Highway Department.

New Year's Day – January 1st
Lincoln's Birthday – February 12th
Admission Day – February 14th
Washington's Birthday –February 22
Memorial Day – May 30th
Independence Day – July 4th
Labor Day – First Monday in September
Columbus Day – October 12th
General Election Day – First Tuesday, after first Monday in November (alternate years)
Veteran's Day – November 11th
Thanksgiving Day – Third Thursday in November
Christmas Day – December 25th

Any holiday falling upon a Sunday will be observed the following day.

VACATION AND SICK LEAVE:

Trainees will accumulate a credit for vacation leave of one and one-half days for each month worked. Such leave is cummulative, however, not more than 30 days can be carried from any calendar year to the next. Sick leave accrues at the rate of one day per month without limit. To insure that training in any division is not slighted, vacation will be limited to two weeks at a time.

PROBATIONARY PERIOD:

During the initial six months of the Trainee's employment with the Highway Department, he accumulates, but is not entitled to use vacation time. Sick leave may be taken after the first 30 days. Any leave other than emergency, and then only with prior approval, sustained during that period, will result in deduction in pay,

The first six months of the Trainee Program shall be considered as a probationary period and unsatisfactory progress or attitude may, at the discretion of the Engineer-in Training Officer, be the basis of dismissal from the Training Program. The Trainee shall have the right of appeal and review by the Highway Commission or its designate. Under such dismissal, the Trainee relinquishes all rights to accrued leave.

LEAVE WITHOUT PAY:

Leaves without pay shall be determined by the immediate supervisor and with the consent and approval of the Engineer-in-Training Officer.

WITHDRAWAL:

Should a Trainee desire to withdraw from the program before the termination date of his agreement, he may be permitted to do so upon the advice and consent of the Engineer-in-Training Officer, subject to the approval of the State Highway Engineer.

SALARY:

Trainees accepted in the Training Program shall be employed at an initial salary of ~~$768.00~~ $813.00 monthly.

IN-GRADE PROMOTIONS:

At the end of twelve months if the Trainee shows satisfactory progress in the program, he will be eligible for an increase in salary to ~~$812.00~~ $859.00 monthly. The salary raise is made effective with the pay period beginning after the end of the stated period.

COMPLETION OF TRAINING:

Upon the completion of training, the Trainee will be assigned to regular duty with a division of the Highway Department. The assignment will be made with consideration for the preference of the Trainee, the Division Heads and the Engineer-in-Training Officer, together with the overall needs of the Department.

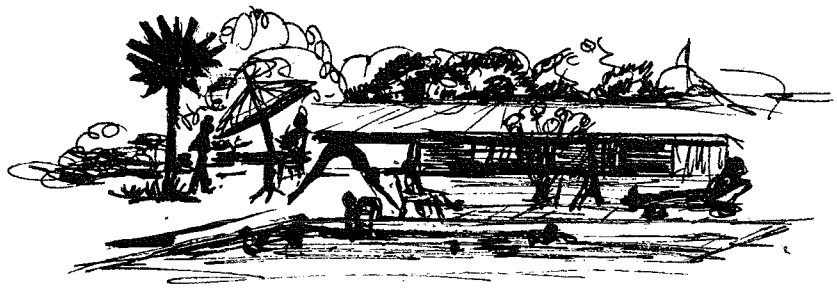
Trainees will be expected to continue in the program until it is completed. The Engineer-in-Training Officer, however, may transfer a Trainee to a regular employee status at any time when such action seems to be in the best interest of all concerned.

RETIREMENT:

All employees become members of the State Employee's Retirement System. Payments to the system are deducted automatically each month. Upon termination of his services with the organization, the Trainee may withdraw that portion of the money which he has contributed to the retirement fund or he may allow it to remain until he reaches retirement age.

SUBSISTENCE:

A Trainee assigned to any division in the Highway Department will be entitled to the same subsistence as is received by the men of that division with whom he is working.



TRAINING SCHEDULE

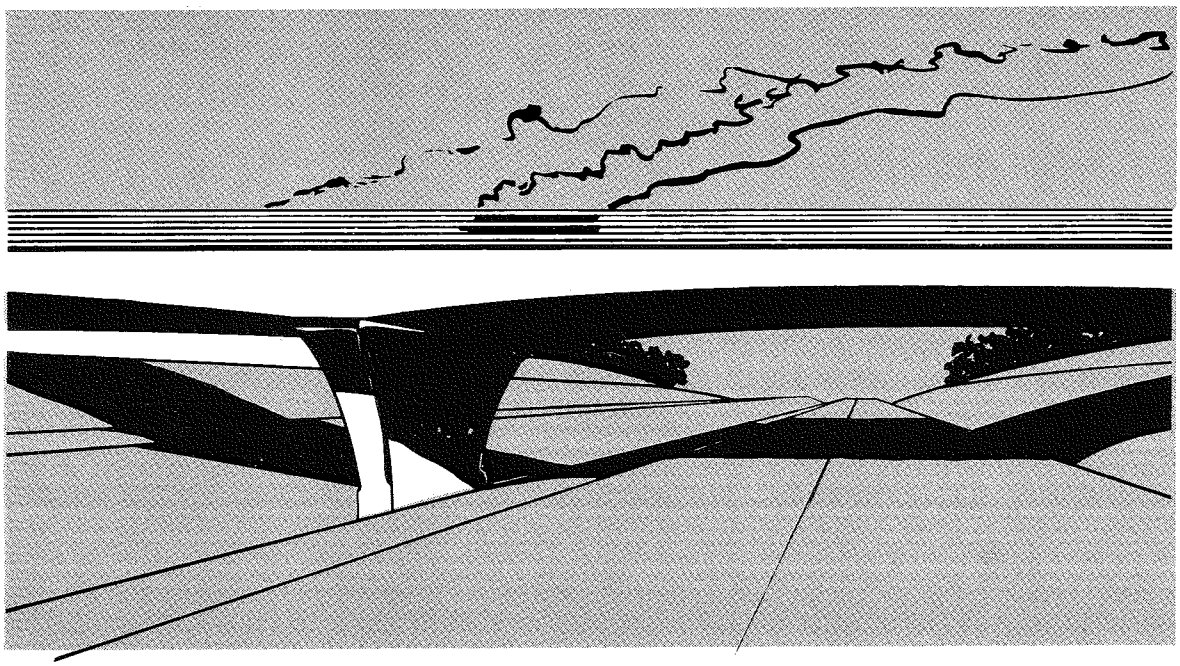
The Engineer-in-Training Program shall extend over a period of eighteen months, divided approximately as follows:

BRIDGE	1	MONTH
CONSTRUCTION	4	MONTHS
DATA PROCESSING	1	MONTH
ESTIMATING	1	MONTH
LOCATION	1½	MONTHS
MATERIALS	2	MONTHS
PHOTOGRAMMETRY	1	MONTH
PLANNING SURVEY	3	WEEKS
PLANS	1	MONTH
RIGHT OF WAY	1	MONTH
ROADSIDE DEVELOPMENT	½	MONTH
TRAFFIC ENGINEERING	1½	MONTHS
LAST 2 MONTHS WILL BE SPENT IN THE DIVISION WHERE EIT WILL BE ACCEPTING A PERMANENT POSITION.	2	MONTHS
	18	MONTHS

The order of assignment and the allotment of time may vary from the above schedule as the occasion demands. Reports from the supervising engineers will be requested on the Trainee's progress and aptitude, after his completion of each phase of the training.

DIVISION ANALYSIS

Following are brief descriptions of each division listed in the Engineer-in-Training Schedule, containing also a program designed to give the Trainee as much experience in this Division as time will permit.



BRIDGES

The Bridge Division is responsible for the preparation of engineering designs and plans for all major highway structures.

The following program is outlined for the Trainee to obtain experience in this Division.

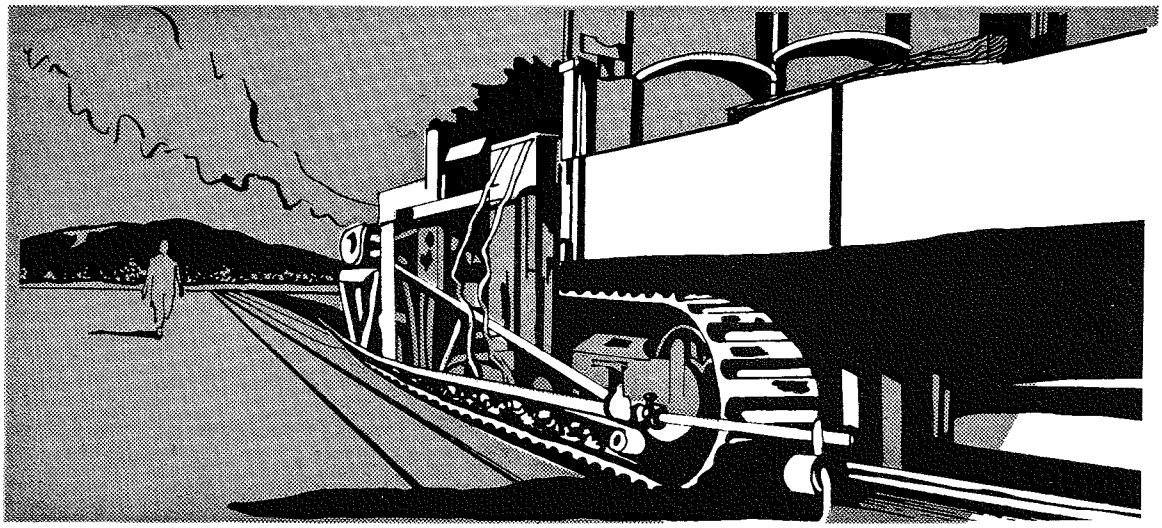
1. Designing or Drafting
    - (a) Bridges
    - (b) Miscellaneous Structures

2. Computations
    - (a) Quantities
    - (b) Estimates, preliminary and final

3. Checking
    - (a) Quantity computations
    - (b) Culvert layouts and details

4. Inspections
    - (a) Structural steel shop
    - (b) Field trips to observe foundation investigations.

5. Outside reading – as recommended.



CONSTRUCTION

All major construction work in Arizona is let out to contracting companies who operate under the close supervision of the District Engineer in the district where the work is being performed.

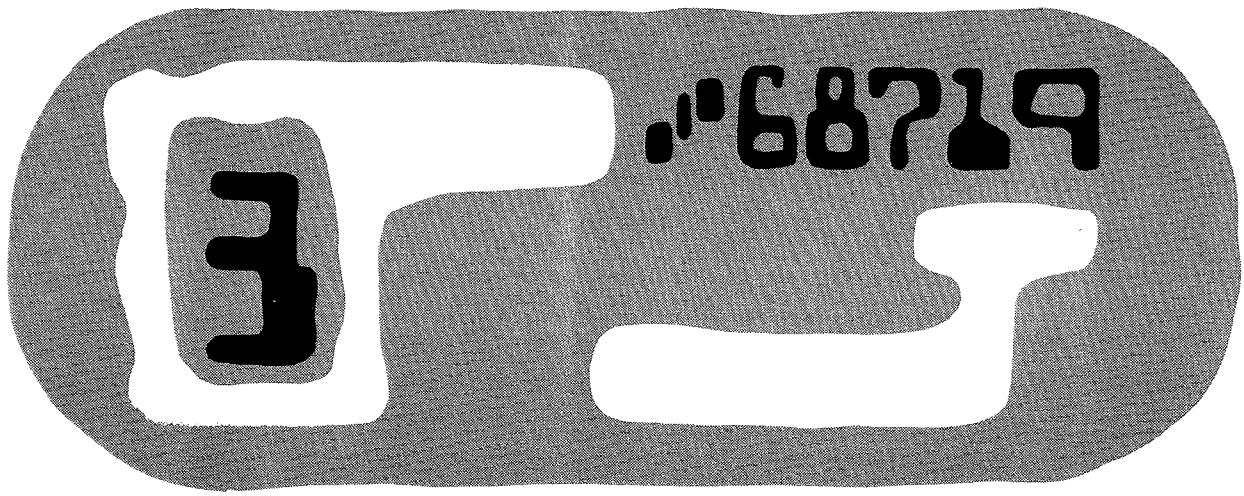
These construction projects are under the personal supervision of a Resident Engineer, who is directly under the Assistant District or District Engineer.

It is the duty of the Resident Engineer and his assistants to stake out and inspect the work being performed; measure the pay quantities and make estimates of work completed. The work is done in accordance with the contract, specifications and plans with payment made at the unit price bid by the contractor.

Arizona State Highway Department maintenance crews may, on occasions, handle the construction of small projects; however, their work deals mainly with maintaining the existing roadways. Maintenance is performed by crews of skilled and unskilled laborers employed by the Arizona Highway Department and living in the vicinity of the section of road on which they are assigned to work. Each crew is supervised by a Maintenance Foreman, who may be responsible for 100 miles of road (more or less).

To provide the Trainee with a good understanding of the functions of a district the following outline is recommended for the 4 available months:

1. Survey Party – 2 months
    a. Running line and Slope Staking
    b. Staking Structures
    c. Blue Topping
    d. Proper handling of traffic through and around construction.
2. Materials Inspection – ½ month
    a. Study of Materials Division Manual for Inspectors
    b. Make routine soil and aggregate tests
    c. Inspect and sample concrete and asphalt mix
3. Field Office – 1 month
    a. Computing grades
    b. Set up Transit and Level books
    c. Prepare field reports
    d. Personnel (Classification – Payrolls)
4. Maintenance and Equipment – ½ month



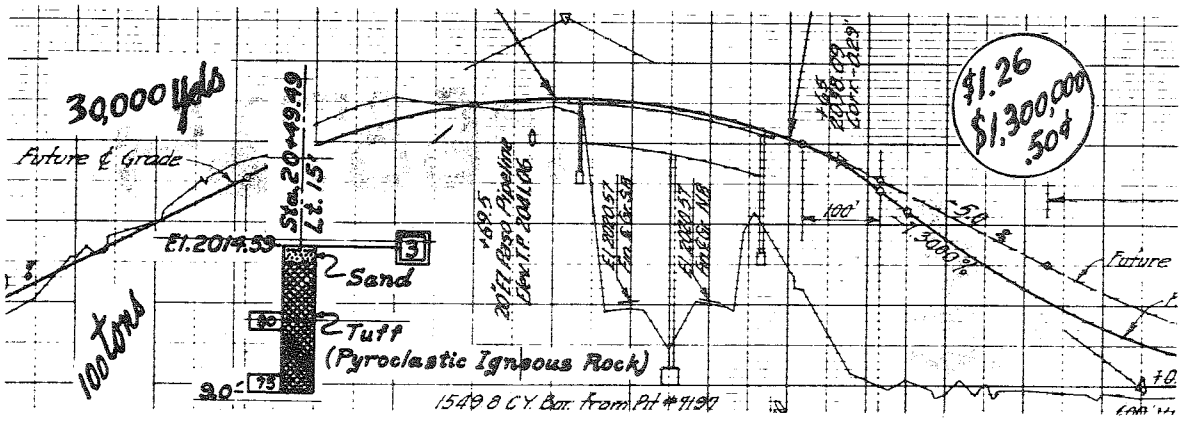
DATA PROCESSING

The Arizona Highway Department pioneered the use of electronic computers in Highway Engineering. During 1956, the first operational computer Earthwork System in the world was put into production here in Arizona. Since this early beginning the Department has installed 5 separate computer configurations which span 1st, 2nd and 3rd generation equipment. Currently installed is a large scale IBM 360 system with multiprogramming and teleprocessing facilities. Plotters and graphic solutions are a part of this system.

Engineers within the various headquarters and District offices have terminals (via phone lines) available for their use to help them solve the variety of Complex Civil Engineering problems encountered today. Several of the Integrated Civil Engineering System (ICES) subsystems that were developed at M.I.T. are currently installed. These include COGO, BRIDGE, STRUDL, ROADS and PROJECT. In addition to the engineering terminals, the Administrative Terminal System (ATS) is helping in the area of text editing and report writing.

The increasing use of computers in solving Engineering problems brought the need to include this division in the Engineer-in-Training program. The prime objective of including this division is to familiarize the E.I.T. with the capabilities and extent to which this equipment is being used throughout the Department. Because our computers are used so extensively, this exposure to the Data Processing function also helps to orient the E.I.T. and broaden his perspective with respect to the overall, complex, interrelationships of the other operating divisions of the Department.

Depending upon the interests of the particular E.I.T., he may pursue learning FORTRAN and accomplish writing a simple computer program or he may study the many engineering programs already available to become familiar with their application to practical problems. Because of the broad scope of current applications and the rapidly changing D.P. environment, a flexible E.I.T. program in this area has emerged.



ESTIMATING

Although the Engineer-in-Training Program lists this Division as Estimating it is actually the Division of Contracts and Specifications.

The responsibility of this Division is to prepare the contracts, specifications and detailed estimates, handle the pre-qualification of Contractors, advertise projects for bids, open and examine bids received and handle all other related work for a proposed highway project.

When a set of completed roadway plans are received in the Division of Contracts and Specifications a well organized schedule is activated. First the plans are given to Estimating Section where a "Take-Off" is performed. This entails the compilation of all "pay items" contained in the plans, including the computation of all surfacing material quantities as well as water and rolling. The Estimator also checks the plans completely to make certain that they conform to all material specifications and to all Right of Way or other Division recommendations. This serves to see that the efforts of all Divisions have been coordinated.

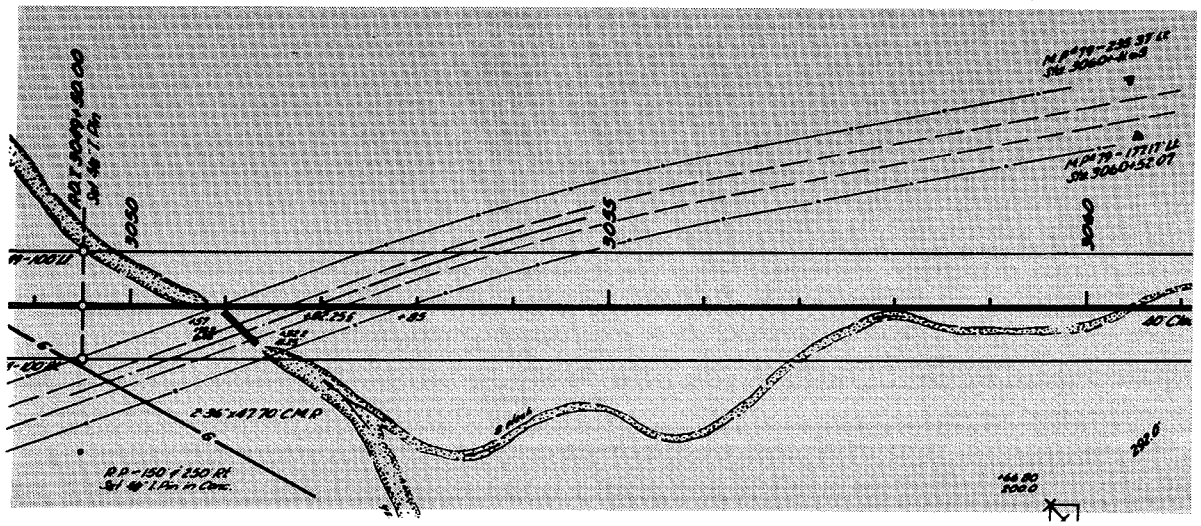
At this point quantities are listed on estimating sheets and an estimate is made for the complete job.

The specification writers are the next on the schedule. Special provisions are written covering any special conditions or agreements that may be included in the project. Right of Way clearance is also checked to make certain that acquisitions are cleared prior to the execution of contract.

After all parts of the plans have been checked the Division issues an advertisement for Bids. There is usually a minimum of three weeks between the date of advertising and bid opening.

The Trainee's stay in this Division will include working in the following phases:

1. Enumeration of bidding items.
2. Computing quantities.
3. Comparing the plans with all division recommendations.
4. Listing quantitites on estimating sheets.
5. A brief introduction into specification writing.
6. Bid openings and checking bids.



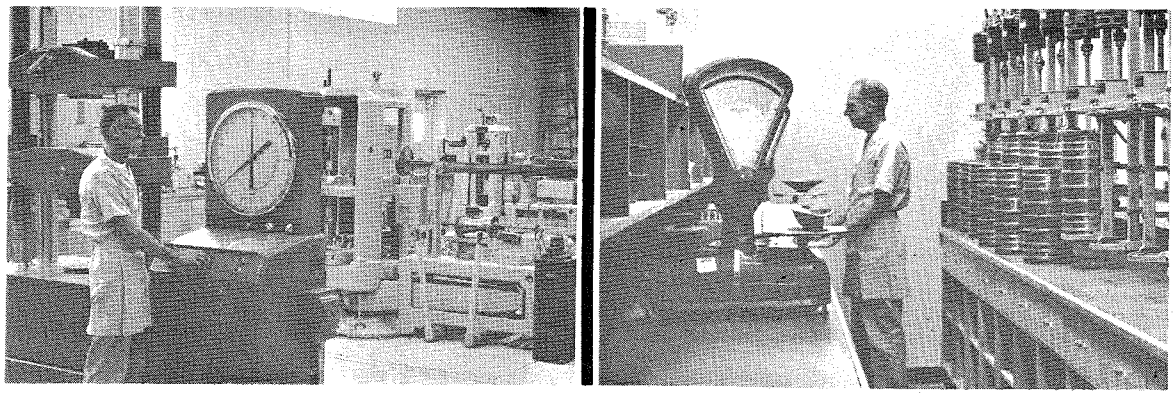
LOCATION

One of the more important Divisions in road building is that of Location.

This Division makes the necessary surveys and furnishes the necessary information for the location and design of roadways and bridges. Because a slight change in the location of a road can cause a tremendous change in its cost, a high amount of proficiency and accuracy is desired in all Location personnel.

A Location crew is expected to understand the principles of highway location and route surveying. They must also be capable of staking out circular curves and spirals, taking topography, locating property lines, survey drainage areas, keeping standard computing quantities and making the bridge situation plans. The Chief of Party must also be capable of making necessary instrument adjustments and know the procedure of taking polaris and solar observations and be well versed in the principles and application of our State plane coordinate system.

In spending the required time in this Division, the Trainee should become quite proficient in his understanding of basic surveying and engineering procedures.



MATERIALS

The Materials Division provides the backbone for all highway construction. This backbone is the material out of which the road bed, the roadway surface and the bridges themselves are constructed.

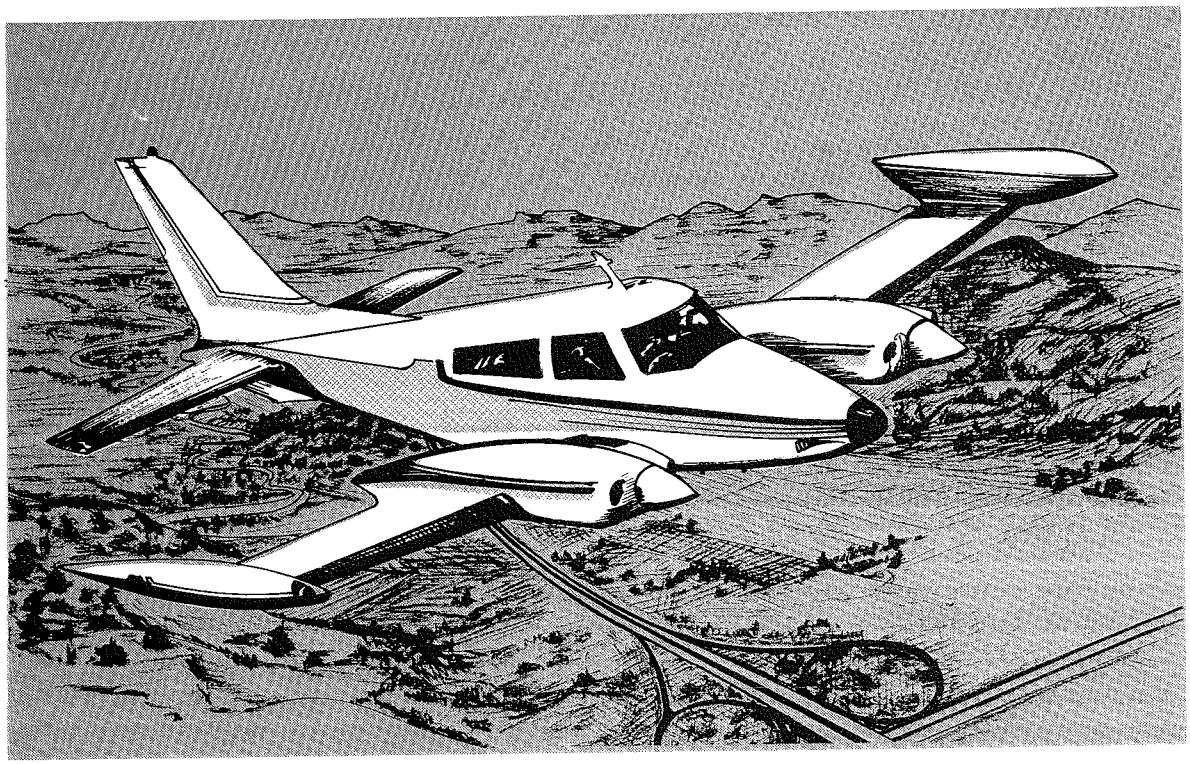
Extensive field investigations, sampling of existing soil conditions and exploration of aggregate sources are made by the Materials Division. Tests using the latest methods are performed by the Division on the samples obtained prior to the design of the roadway. From the result of these preliminary tests, recommendations are made in the form of a materials Design Memo concerning the safe slope for cuts and fills, the expected shrinkage and swell of the material, determination of pavement type, the most economical roadway section, the location and approximate amount of suitable materials for the various roadway requirements, the base thickness, the type and thickness of surface, the type of seal coat, and any other information along this line that may be required.

The Materials Division also has the responsibility of control over all the material as it is used in the field of construction. Field material tests include taking samples of cement, sand, gravel, concrete, steel, culvert pipe, paint, wire, sub-grade, borrow, base materials, road oils, asphalt mixes, water and other items.

The base materials and aggregates are usually controlled by field tests performed in field material labs, however, these tests are subject to a systematic check by the Materials Division in Phoenix.

During his assignment in this Division, the Trainee will:

1. Make a study of the test methods related to the following materials:
    a. Aggregates
    b. Soils
    c. Cements
    d. Concrete
    e. Bituminous Materials
    f. Asphaltic Contrete Mix Design
    g. Chemical Testing
    h. Infrared Spectrophotometer
    i. Research and Special Studies
    j. Standardization and Calibration of Testing Equipment
2. Be given instruction in the interpretation of Test Results
3. Study and receive instructions covering materials.
4. Study Materials Surveys:
    a. Preliminary investigations
    b. Soil profiles
    c. Pavement evaluations
5. Study Quality Control Methods.



PHOTOGRAMMETRY

The Photogrammetry and Mapping Division is responsible for the production of maps of the various types and scales needed by the Department for planning, location design and special study of highways in all areas of the State.

The County Mapping Section of this Division produces the series of county atlases which will cover the entire state with accurate small scale planimetric maps. The process by which these maps are made includes such steps as acquiring aerial photography, photo identification of control, base sheet layouts, field edit, scribing, nomenclature research, color separation and final edit. These maps are produced primarily for highway planning; however, the side benefits are many and the published maps are available for sale to the general public.

The Photogrammetry Section of the Division produces specific topographic maps as needed on specific projects. These maps contain much of the basic information needed to locate and design new highways. Grades, cross sections, drainage areas, structure profiles and much other data can be determined to accuracies required.

The above work is accomplished through use of several field survey parties modern surveying equipment, aircraft, aerial camera, photo lab, geodetic computation utilizing electronic computers, stereo plotting and final drafting.

The Planning and Research Section is subdivided into the Special Studies, Traffic Analysis, and Research and Standards units.

The Special Studies unit is responsible for conducting special traffic engineering studies in cooperation with the Bureau of Public Roads. Under the Civil Defense function, the Special Studies unit is responsible for the preparation and maintenance of emergency highway traffic regulations. This unit also conducts safety implementation studies which may be required under the National Highway Safety Standards.

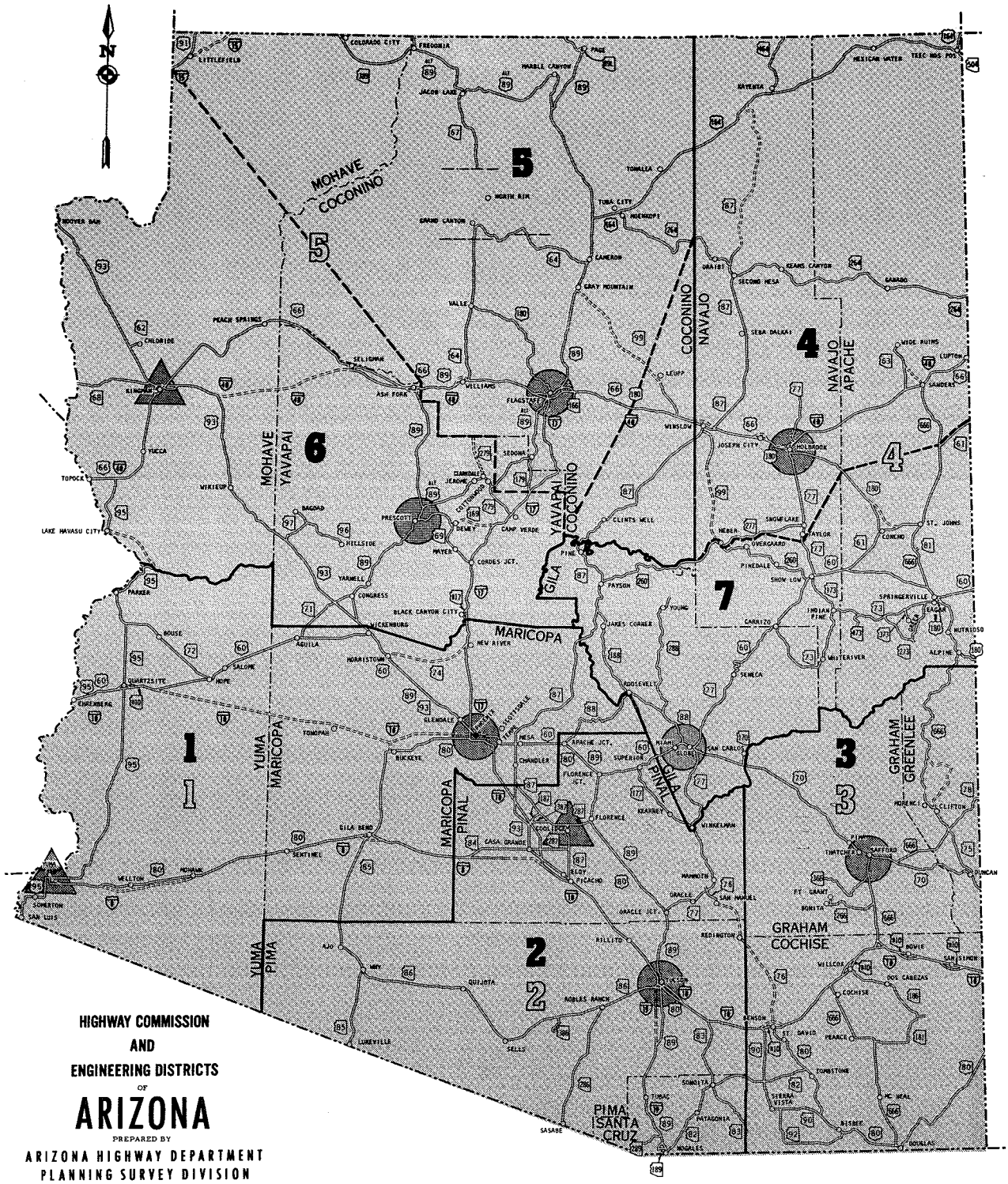
The Traffic Analysis unit is responsible for the development of factual and statistical records pertaining to accidents and traffic volumes on the State Highway System. These data are used within the Traffic Engineering Division to help determine the need for new traffic controls, and to analyze the effectiveness of traffic engineering improvements. These data are also made available to other agencies.

The Research and Standards unit is responsible for the development of engineering standards within the Traffic Engineering Division. These include such standards as delineation, pavement markings and traffic controls for highway construction and maintenance operations. In addition, this unit is responsible for the evaluation of operational research. Research conducted by other agencies is reviewed for applicability in Arizona.

The **Administrative Assistant** to the Traffic Civil Engineer coordinates and provides administrative services to the Division in the areas of budget preparation, procurement of materials and operating equipment, inventory, accounting, and personnel.

The following assignments are among those given the Trainee in the Traffic Engineering Division:

1. Orientation – Traffic Engineering Division – 1 day
2. Design Branch – 5 days
    a. Plans Review
    b. Signing Design
    c. Accident Analysis
    d. Volume Analysis
    e. Research and Standards
    f. Special Studies
3. Operations Branch – remainder of time
    a. Signals and Illumination
        1. Design
        2. Signal Operation
        3. Construction and Maintenance
    b. Signing and Striping
        1. Sign Shop
        2. Signing Field
        3. Striping Field
    c. Operations Studies
        1. Signing and Channelization
        2. Speed Zoning
        3. Studies
        4. No-Passing Zones



HIGHWAY COMMISSION
AND
ENGINEERING DISTRICTS
OF
ARIZONA

PREPARED BY
ARIZONA HIGHWAY DEPARTMENT
PLANNING SURVEY DIVISION

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SCALE - MILES

1970
LEGEND

- DISTRICT ENGINEER
- ASSISTANT DISTRICT ENGINEER
- 1 — COMMISSION DISTRICT NUMBER
- 7 — ENGINEERING DISTRICT NUMBER
- COMMISSION DISTRICT BOUNDARY
- ENGINEERING DISTRICT BOUNDARY (OTHER THAN COMMISSION DISTRICT BOUNDARY)

COMMISSION DISTRICT	ENGINEERING DISTRICT	COMMISSIONER	DISTRICT ENGINEER
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2	2	Lew Davis, Tucson, Member	John Kulinovich
3	3	Peter B. Wilharm, Benson, Vice-Chairman	W.O. Ford
4	4	Walter W. Surrett, Payson, Member	E.F. Gentsch
5	5	Ed. C. Locklear, Prescott, Chairman	John Chapman
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4	7	Walter W. Surrett, Payson, Member	G. Ohnesorgen